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Associative Symmetry and the Re-Paired Paradigm

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ASSOCIATIVE SYMMETRY AND THE RE-PAIRED PARADIGM

by

Richard C. Ney

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CHAPTER I

Associative Symmetry: Fact or Fiction

The history of the bidirectional learning problem has been both prolific and controversial. In contemporary verbal learning, associative symmetry has remained an unsolved problem despite volumes of publications dealing both with the variables and dynamics of the problem. As stated by Ekstrand (1966), it is known that as a S forms a forward association (A-B) between two verbal elements, he learns to anticipate the B unit given A as the stimulus. However, a question arises as to the formation of the so-called backward association. Does the S learn a corresponding backward association (B-A) coincidentally with the forward association? Research seems to indicate that the S has learned two associations, but controversy arises over the symmetry of this association and the point at which the backward associations are formed.

The principle of associative symmetry, as defined by Asch and Ebenholtz (1962), states that as a S learns a particular forward association (S-R), he learns a corresponding backward association (R-S). This backward association was proposed to be coincident with and equal in strength to the learned forward association. Thus, they hypothesized that the associative stages of both forward and backward learning were functionally identical; however, unequivocal support for their hypothesis was not presented. Of the seven experiments reported by Asch and Ebenholtz, six experiments demonstrated superior A-B performance over the corresponding backward (B-A) performance. Although the experiments explained this failure to confirm the symmetrical learning in terms of stimulus-response availability, the principle of

associative symmetry remained questionable.

Earlier researchers demonstrated that a degree of A-B/B-A learning did occur, but not of the magnitude suggested by the principle of complete associative symmetry. Jantz and Underwood (1958) gave Ss a paired-associative (PA) list consisting of nonsense-syllable and adjective pairs. Initial learning was stopped at 4, 8, 12, or 24 A-B trials at which time the Ss were given 10 trials of B-A learning using standard paired-associate procedures. The results showed B-A learning performance to be a function of the number of A-B learning trials but that asymptotic behavior for the B-A learning was much lower than that for A-B learning. Although B-A learning increased as first list learning increased, B-A transfer learning never reached the level of A-B learning. Similarly, Feldman and Underwood (1957) and Morikawa (1959) found that B-A performance was related to the degree of A-B learning but that the forward and backward associations were far from equal or identical. Because of the observed relationship between A-B/B-A learning, it was, in fact, suggested that B-A performance might be a form of incidental learning.

The lines on either side of the bidirectional learning issue, then, have been clearly formed. The first part of the present paper examines the concept of bidirectional learning and related research. The methodological issues involved in the controversy are: meaningfulness (M), stimulus availability, A-B association equivalence, and stimulus-response equivalence. Bidirectional learning will also be discussed in relation to paired-associate transfer tasks and the further implications between transfer paradigms and bidirectionality. Finally, data will be presented in which forward and backward associations are equal in strength and functionally identical.

Early Studies in Bidirectional Learning

Research dealing with the issue of forward and backward associations can be traced at least as far back as 1913 when Wohlgemuth presented data on memory and the directions of associations. Wohlgemuth noted that although retrieval of learned materials was usually in a forward direction, there was, to some extent, a degree of association to items learned earlier in a sequence in relation to the item being recalled. For example, if an individual learned the sequence A-B-C, given B as a stimulus C would usually be recalled. However, some association, it was hypothesized was present between B and A. Citing earlier evidence from both physiological and learning theory, Wohlgemuth took issue with the generally accepted notion of greater strength in the forward association. Using both diagrams and nonsense syllables, Ss were given a successive and continuous series of items to learn. Following initial learning the S was given the task of responding to the stimulus term with a related term (defined as an item immediately preceding or following the stimulus term in the sequence). The S was told to respond as soon as the item (diagram or nonsense syllable) came to mind. The results showed that there was a greater tendency for forward recall with syllables than with diagrams. It was further noted that backward direction recall was stronger with three of seven Ss tested. It was concluded that an unconscious bias to react in a certain direction exists in individuals with the forward direction bias being the strongest tendency. However, evidence for backward direction learning was found especially when diagrams were used as the to-be-learned material. In a subsequent experiment Wohlgemuth (1913) used diagram and color pairs as the to-be-learned material. Data from the experiment indicated that

"associations formed between colors and diagrams were equally strong in the two directions."

Stoddard (1929) used the learning of French and English word equivalents as a measure of learned association strength. Although measuring the relative strength of forward and backward associations was only a part of the experimental procedure, his data is most applicable to the experiment presented in the present paper. Two groups were given 50 word pairs to learn with direction of learning being reversed for the two groups: French to English or English to French. Following a learning period of 20 minutes, the Ss were given a 50 item test consisting of 25 French words and 25 English words and asked to supply the corresponding English or French equivalent. For one half of the items, then, recall was in a backward direction. The data showed that for both groups forward recall was significantly better than backward recall, although a certain amount of backward recall was noted.

Hermans (1936) using nonsense syllable pairs as terms in a sequence task found marginal evidence for bidirectional learning although forward associations were recalled more frequently than backward associations. Guthrie (1933) presented four groups of 12 Ss each with the task of learning 10 pairs of nonsense syllables and nonsense figures. The pairs were photographed on standard motion picture film and projected on a screen by a projector operated by a synchronous motor. Exposure time and the interval between pair exposures was independently manipulated for three separate time intervals: 4.93, 3.33, and 2.55 seconds. Each group of Ss was given two lists to learn, one with a word-figure pairing and one with a figure-word pairing. Following seven trials of list learning, the Ss

were given the task of writing the names of the figures that were slowly being projected on a screen. Thus, each group of Ss was given one series for forward associations and one series for backward associations during initial pair learning. For the 4.93, 3.33, and 2.55 exposure intervals, the mean number nonsense syllables recalled for forward and backward associations were respectively 5.40 and 5.48, 4.92 and 4.90, and 3.35 and 3.38. The data indicated that association strength was a function of interval time, but that forward and backward associations were functionally equivalent across interval times.

Bidirectionality as Incidental Learning

Following the controversy between early researchers in the area of bidirectional learning, experimenters directed their attention to the nature of the "backward" association. Hermans (1936) had selectively eliminated those Ss who reported intentional learning in both the forward and reverse direction. It was suggested that somehow the formation of backward associative bonds should be incidental to the intentional task given to the S.

Controversy concerning the existence of bidirectional associates continued for several years with equivocal evidence being presented for both sides of the bidirectional issue (Harcum, 1953; Morikawa, 1955; Prioff, 1938). However, for the purposes of the present analysis it was not until the late 1950s that methodological sophistication allowed for a proper testing of bidirectional learning. At this time data unequivocally supported the hypothesis that Ss do learn two distinct associations (forward and backward) in a paired-associate learning task. However, the question remained unanswered as to the relative strength and onset of these

associations. Further, it was unclear whether or not the two directions of associations were formed by two separate learning processes or if the associations were functionally identical.

Later researchers followed the tradition of the above mentioned experimenters and suggested that bidirectional learning was indeed a form of incidental learning. It was suggested that given the task of learning a set of A-B associations a S would incidentally learn the B-A association. However, the strength of the B-A associative bond would not match that of the intentionally learned A-B association. It was further suggested that B-A learning would asymptote at a level significantly lower than that of A-B learning (Jantz & Underwood, 1958).

Following the incidental learning argument, Feldman and Underwood (1957) studied the phenomenon of R-S learning. Incidental learning was defined as the learning of material by a S when he was not specifically instructed to do so. It was, however, suggested by the authors that high recall of R-S associations might suggest that S-R and R-S associations might be integrally connected and that the formation of backward associations was something more than an incidental learning phenomenon. The authors reported that Thornton in an unpublished study from the Northwestern University laboratories had found an 83% recall of stimulus items following a standard paired-associate learning task. In the Feldman and Underwood experiment the stimuli were nonsense syllables with an average association value of 11.4% (Glaze), and the responses were adjectives. Thirty Ss were assigned to each of four conditions varying on a dimension of high or low stimulus and response similarity. The four groups were HS-HR, HS-LR, LS-HR, and LS-LS where H referred to high similarity, L referred to low

similarity, S to stimulus, and R to response. After learning the original list to a criterion of two successive perfect trials, S was given the adjective responses at a 4-second rate and asked to give its associated nonsense syllable stimuli. Following this type of recall, the Ss were given an unlimited time for a modified free recall. The results showed that high stimulus similarity had a small but consistent effect of reducing stimulus recall. The overall recall of stimulus terms was 50% of the items learned. Partial recall of the stimuli, defined as the recall of one or two of the stimulus letters in the correct position, yielded a recall value of 61%. Evidence was presented, then, suggesting that backward recall was somehow related to forward recall, but not as an integral part of the intentional learning task.

Jantz and Underwood (1958) found that B-A performance increased with the degree of forward learning but that the R-S recall was considerably lower than S-R recall. Leicht and Kausler (1965) gave Ss 6, 12, 18, or 30 trials (or up to one perfect trial, whichever came first) on an A-B learning task. Following original list learning, the Ss were given a recognition task in which each response was presented along with three alternative stimuli. The S was to choose the stimulus which was originally paired with the given response. As with incidental learning tasks, the B-A performance was found to be a direct function of the number of A-B trials. However, the above experiment yielded equivocal results in that the Ss could have been subtly testing the forward associations while performing on the recognition task. Morikawa (1959) also reported increased B-A performance as A-B learning increased but again B-A performance was not equal to that of A-B learning. Subsequent studies also failed to yield

complete stimulus recall in a standard A-B, B-A test of associative symmetry (Houston, 1964; Murdock, 1964).

Schild and Battig (1966) presented two experiments in which Ss were required to learn unidirectionally (U) in a paired-associate task or bidirectionally (B) where each pair was presented in both directions (A-B and B-A) during the learning trials. Unidirectional performance was significantly better than B performance particularly in errors on trials after the first correct response to each pair when directionality was reversed. The results were interpreted to mean that Ss in the B condition were forced to learn two separate associations and thus the A-B, B-A associations were not functionally equivalent.

In a similar experiment, Voss (1965) attempted to eliminate differential A-term learning by requiring both groups (U and B) to learn in the same direction. Bidirectional learning was introduced by the way the pairs were presented (A-B or B-A) following each anticipation. The results showed poorer correct response and error performance with bidirectional pairing suggesting that bidirectional and unidirectional pairings were not equivalent and, therefore, associations were not learned bidirectionally. Other experiments have also reported data supporting the notion that forward and backward associations were functionally different (Goulet & Behar, 1966; Leuba, 1966; Sepal & Mandler, 1967; Underwood & Keppel, 1963).

Associative Symmetry: Defined and Confirmed

Despite the large number of studies suggesting that the formation of forward and backward associations were two distinct processes, several studies have concluded that Ss do indeed learn symmetrically. As defined by Asch and Ebenholtz (1962), the principle of associative symmetry states

that: "When an association is formed between two distinct terms, a and b, it is established simultaneously and with equal strength between b and a (p. 136)." As defined, the principle states that the learned association between A-B and B-A are functionally equivalent. If this principle is to be proven then the data from experiments must show that A-B and B-A performance is equal or that the R-S/S-R recall ratio is 100%.

The negative findings of earlier experiments have been criticized on the basis of the availability of the stimulus terms. As noted by Underwood (1963) Ss frequently choose a functional stimulus different from the nominal stimulus presented by the E. The nominal stimulus, then, might not be available to the S during the backward recall of the stimulus term. Thus, Asch and Ebenholtz felt that any differences between A-B and B-A performance was due to differences in stimulus or response learning but not in the learning of the associative bond.

Asch and Ebenholtz (1962) found that through a prefamiliarization technique whereby Ss learned the stimulus and response terms prior to association learning, the difference between A-B and B-A performance could be reduced. Leicht and Kausler (1965) found that by reducing the disparity between the nominal and functional stimuli the difference between A-B and B-A performance could be substantially reduced. This disparity was reduced by giving S a recognition transfer task; however, caution must be used in interpreting their data due to the possibility of covert forward association rehearsal during the recognition task. Nelson, Rowe, Engel, Wheeler, and Garland (1970) postulated that stimulus recall is directly related to the degree of meaningfulness in the stimulus component. The results of the study indicated that increased meaningfulness

in the stimulus terms reduces stimulus fractionation and increases stimulus recall. Horowitz, Norman, and Day (1966) noted, in a review article, that A-B and B-A associations could be equally strong, but that B-A associations only appear weaker due to the lack of availability of the stimulus terms for recall. Thus, a number of studies have noted the importance of the stimulus component as it related to availability and subsequent recall.

In a study relating item meaningfulness and S-R, R-S acquisition, Harrigan and Modrick (1967) compared the Underwood and Schulz (1960) unidirectional model of learning with the symmetry model of Asch and Ebenholtz (1962). It was hypothesized that the unidirectional model proposes two stages of paired-associate learning: response (R) learning and association (S-R) learning. The symmetry model, however, proposes two additional stages: stimulus (S) learning and (R-S) or backward association learning. It was further hypothesized that S-R and R-S learning are equivalent. The learning of paired-associate material, it was hypothesized, would follow one or the other model as a function of the meaningfulness of the items to be learned. The data showed that the symmetry model obtains for high meaningful material whereas, the two stage model of Underwood and Schulz applies to the learning of low meaningful paired-associate items. The results of this experiment could be interpreted as support for the notion that item availability is crucial to a test for associative symmetry.

The above research data substantiated the results of an earlier study by Asch and Lindner (1963). This study confirmed the principle of associative symmetry, but only under very specified condition of item

availability. If items are differentially available following paired-associate learning, apparent asymmetry obtains. However, if both stimulus and response items are made equally available through familiarization, the formation of forward and backward associations function identically.

From a different viewpoint, Wollen, Fox and Lowry (1970) substantiated the principle of associative symmetry but only under very specified conditions of prior A-B original list learning. The design included factorial combinations of noun imagery (high vs. low) and testing direction (forward and backward). It was hypothesized, moreover, that associative symmetry would result when forward learning was either high or low. Learning performance was measured from trial one to a criterion of one perfect trial. The results confirmed the hypothesis and further showed that asymmetry results when A-B learning was intermediate between a very low or very high number of original list learning trials. Data showed that for low and high imagery there was virtually no difference between forward and backward curves when forward learning was low or high. In general, then, the principle of associative symmetry was confirmed under specified conditions.

Two studies which further confirmed the symmetry model of paired-associate learning were Murdock (1956) and Ney and Solso (1972) both of which used negative transfer paradigms as measures of associative symmetry. Murdock (1956) measured the B-A transfer paradigm against a reversed and repaired paradigm (B-Ar). The difference between the two conditions was highly significant $p < .01$. This significant difference was said to confirm the learning model of Asch and Eberholtz. The study by Ney and

Solso (1972) used a different method of comparison. The B-Ar paradigm was compared to the standard repaired paradigm A-Br. It was hypothesized that if the principle of associative symmetry were operative in paired-associative learning, then the two repaired paradigms would show equal negative transfer in relation to a C-D control paradigm. If associative symmetry were not a valid principle of learning, then the B-Ar paradigm should show less negative transfer than the A-Br paradigm. The data confirmed the hypothesis that negative transfer was evident throughout learning trials with both negative paradigms reaching asymptotic behavior equal to that of the C-D control.

The previously mentioned research experiments have differentially proved or disproved the symmetry issue depending on the materials used and the methodology employed. However, as mentioned by Ekstrand (1966) the vast majority of experiments dealing with bidirectional learning have certain methodological flaws. These flaws include such things as failure to equate stimulus and response terms, failure to insure stimulus availability, and failure to equate for first list learning. The following chapter deals with the methodological problems involved in the study of bidirectional learning and how various research studies have attempted to answer the critical problems outlined by Ekstrand (1966).

CHAPTER II

Methodological Problems in B-A Learning

Variables affecting B-A learning

If the incidental versus symmetrical learning issue is to be resolved, the effects of other variables on B-A learning performance must first be determined. Ekstrand (1966) stated that if A-B strength is not equal for the different levels of a variable or if A-term availability is not equal, then no definitive conclusion can be drawn concerning the direction and strength of the associative stage. Ekstrand further noted that a majority of previous experiments had methodological problems with regard to stimulus availability and/or A-B (forward) degree of forward learning or both. These confounds precluded a clear interpretation of the data, and thus the case of symmetrical learning remained equivocal. The effects of meaningfulness (M), stimulus-response similarity, and stimulus-term pronunciation on backward recall must be determined before conclusions can be drawn concerning associative symmetry as a valid rule of learning. In addition to the above mentioned methodological considerations, attempts must be undertaken to insure response equivalence in order to determine the most adequate design for the testing of A-B, B-A learning.

Several studies have shown that increasing stimulus meaningfulness increases the percentage of backward associates recalled (Cassam & Kausler, 1962; Epstein, 1962; Leicht & Kausler, 1965). This finding is consistent with the incidental learning argument which would predict an increase in reported backward associations with increasing meaningfulness. However, the majority of previously published articles specifying the effect of meaningfulness on B-A performance failed to equate for the degree of forward

learning (Ekstrand, 1966). Increases in the percentage of backward recall were found to be negatively correlated with the trials to criterion on the original learning list (Cassem & Kausler, 1962; Epstein, 1962). The paired-associate pairs with high meaningful stimuli were learned significantly faster than the pairs composed of intermediate or low meaningful stimuli. Underwood (1964) noted that final degrees of learning differ when the rates of approach to a criterion are substantially different. It was postulated that the group reaching criterion first would show a higher degree of initial learning. Thus, in the experiments of Cassem and Kausler (1962), Epstein (1962), and Leicht and Kausler (1965), the increase in backward performance might be postulated to be due to differences in degree of initial learning and not due to meaningfulness as such.

Jantz and Underwood (1958) manipulated both the degree of forward (S-R) learning and stimulus meaningfulness. The Ss were given 4, 12, or 24 trials on an A-B list and then transferred to a B-A list. The control conditions were also given 4, 12, or 24 trials on a comparable paired-associate list and then transferred to the B-A list of the experimental groups. In effect, the control groups were being transferred to a new S-R learning list. Within each paired-associate list, meaningfulness was manipulated for each of the experimental and control conditions. Four levels of meaningfulness were represented in the eight stimuli used: 0%, 33%, 67%, and 100% (Glaze, 1928). These nonsense syllables were paired with eight adjectives with four different pairings being used in order to eliminate possible confounds due to pairing difficulty. The results showed a significant effect due to both degree of initial learning and

stimulus meaningfulness. However, Ekstrand (1966) observed a confound which existed in degree of A-B learning. During the learning of the initial paired-associate lists, the high meaningful stimulus pairs were presumably learned faster than the low or intermediate stimulus pairs. Thus, any differences in B-A learning may have been due to differences in initial A-B learning.

In terms of A-B presentations, the Jantz and Underwood (1958) study was also confounded according to stimulus availability. Because the SS were not taken to a specified criterion of one perfect trial, dubious conclusions can be drawn as to the availability of the stimulus term for recall after each of the forward learning conditions (4, 12, or 24 A-B trials). The differences in R-S recall for the three experimental conditions might have been due to differential stimulus availability and not the degree of associative learning. A similar criticism could also be given for the Leicht and Kausler (1965) study. As noted by Ekstrand (1966), other studies have similarly shown methodological confounds due to degree of A-B learning (Hunt, 1959; Morikawa, 1959; Newman & Gray, 1965; Richardson, 1960).

Stimulus Availability

Clearly one methodological problem that must be clarified, then, is the problem of stimulus availability. In an attempt to increase functional stimulus recall, Leicht and Kausler (1965) used a recognition task. It was found that due to stimulus fractionation SS may select a functional stimulus other than the nominal stimulus as selected by the E. The results of the Leicht and Kausler study, which controlled for guessing, showed that a recognition task could substantially increase nominal stimulus

recall.

One of the conditions suitable for functional stimulus selection is low meaningfulness or low pronounceability. Newman and Gray (1964) found that Ss reported most frequently responding to a part of the stimulus term under conditions of low pronounceability (a CCC nonsense syllable); whereas, under conditions of easy pronounceability, Ss reported most frequently responding to the entire stimulus term. From a methodological standpoint, the most important finding of the Newman and Gray study was that under conditions of hard pronounceability, fractionation tended to occur only in the stimulus term and not in the response term. This finding may indicate that the task demands of paired-associate learning encourage the subject to articulate and learn the entire response term. The same does not seem to be the case for the learning of the stimulus. The discrepancy between S-R and R-S recall in past studies may be interpreted to be the result of differential stimulus encoding and not a difference in the associative stage. Other studies have found that under specified conditions conducive to low nominal stimulus learning, fewer stimuli are recalled than responses (Battig, Brown, & Nelson, 1963; Morikawa, 1959; Newman, Cunningham, & Gray, 1965). Previous studies have indicated, then, that high stimulus availability must be a prerequisite to the study of associative symmetry (Guirintano, 1972).

Using nonword CVC nonsense syllables as stimuli, Schild and Battig (1966) found unidirectional learning performance was significantly superior to the bidirectional learning conditions for total errors on all trials. However, as previously noted, stimulus fractionation occurs when the meaningfulness of the stimuli is low. It is possible that the apparent

superiority of the unidirectional learning versus the bidirectional learning was a function of stimulus fractionation. In the bidirectional learning condition the ss were forced by the task demands to learn the entire stimulus and response term; whereas, the unidirectional group might have fractionated the stimulus term and used a portion of the CVC as the functional cue for the response.

Recognizing the possibility of the idiosyncratic availability of the CVC pairs, Schild and Battig conducted a second experiment in which word versus nonword pairs were compared in relation to their differential effects on uni- versus bidirectional learning. Bidirectional learning inferiority for the word list was eliminated and this finding was interpreted as being consistent with the Asch and Ebenholtz (1962) hypothesis of associative symmetry. The differences between A-B and B-A associations might then have been a consequence of availability differences for the A and B items. However, the results of the Schild and Battig study gave, at best, tentative support to the associative symmetry hypothesis. The word lists were so easily learned that 57.8% of the pairs were given correctly on the first trial before the directionality differences were introduced and 14 of the 32 ss performed errorlessly on or before the second trial. In light of the previous experiment it was concluded the principle of associative symmetry was confirmed and that the word versus the nonword conditions did not present an adequate test of the associative symmetry hypothesis.

Horowitz, Norman, and Day (1966) emphasized that A-B and B-A associations may be equal, but that the unavailability of the nominal stimulus term for recall artificially produces lower R-S learning performance than S-R performance. Recognizing the fact that lack of stimulus

availability may have accounted for previous failures to obtain symmetrical learning, Wollen (1968) used highly available stimulus-response materials in an effort to test the principle of associative symmetry. In addition, Wollen also recognized that a slow rate of recall could result in the covert rehearsal of the forward association. Therefore, the highly available PA pairs (odd-even number combinations) were presented at fast rates in both acquisition and recall. Experiment I used a visual presentation of the stimuli alone for $\frac{1}{2}$ sec. and the stimulus-response pair for $\frac{1}{2}$ sec. with no intertrial interval. The recall presentation, both forward and backward, proceeded at the same rate as above and continued for two trials with no intertrial interval. The results showed that significantly more S-R associations were recalled than the corresponding R-S associations. In experiment II an auditory presentation of the stimuli-response pairs with a 1 sec. recall rate yielded similar S-R recall superiority. When two additional trials at a 2 sec. rate were given to the Ss the S-R superiority was reduced. Wollen interpreted the data as contrary to the principle of associative symmetry and suggested that the slow rates of presentation in previous experiments were responsible for the apparent confirmation of associative symmetry.

In an earlier study Wollen and Gallup (1965) found indirect evidence for a type of intratrial repetition to which Ss covertly rehearse each pair several times before proceeding on to the next pair. This rehearsal takes the form of a serial learning list in which the stimulus both precedes and follows the response term (e.g., S-R-S-R-S-R). In an effort to empirically test for the presence of the intratrial rehearsal (ITR), Wollen and Gallup (1968) presented a study in which the ITR was "built in" to the experiment

by having the Ss overtly rehearse each pair three times before advancing to the next pair. The stimuli and responses were highly available AA nouns taken from the Thorndike-Lorge count. The problem of differential stimulus availability had to be accounted for if the effect of presentation rate was to be empirically tested. A rapid presentation rate was used ($\frac{1}{2}$ sec.) with 2 sec. rate being used for the test recall trials. In order to equate the groups for the number of item presentations, the Ss in the nonrepetition condition (NR) also received each pair three times per trial but with at least one intervening pair between the repetitions. The data showed more R-S recall for the ITR condition than for NR condition despite the fact that all Ss learned to the same initial S-R criterion. The results indicated that stimulus availability was not a sufficient condition for the demonstration of associative symmetry. However, some reservation must be taken in the interpretation of the data. The data showed evidence of faster learning in the ITR condition versus the NR condition on a trials to criterion measure of initial list learning. Underwood (1964) stated that the group reaching criterion first may have a higher level of S-R learning. Although evidence from two control groups indicated that the differences in initial S-R learning was minimal, caution must be taken in interpreting the ITR as the basis of associative symmetry findings. Secondly, due to the nature of the task, this experiment may be primarily measuring the effect of massed versus distributed practice on R-S recall and only secondarily determining the learning strategies of Ss in bidirectional learning experiments.

Other studies have attempted to increase stimulus availability by using criterion other than frequency or meaningfulness. Wollen, Fox, and Lawry

(1970) used stimuli and responses which were either high (6.49) or low (3.10) in imagery (Paivio, Yuille, & Madigan, 1968). Their data showed no effect for the imagery variable on forward or backward learning when forward learning was low (20% complete) or high (98%). The use of highly available nouns may have overshadowed the effect of imagery on stimulus or response recall. Differences between forward and backward recall were found, however, at the intermediate points of original list learning. The results of the experiment were discussed in light of previous failures by other experimenters to obtain associative symmetry. Ney and Solso (1972) used highly available nouns (above 6.50 in imagery and concreteness) in an effort to reduce stimulus fractionation. Using a backward re-paired paradigm (B-Ar) as a measure of backward learning, Ney and Solso found evidence for associative symmetry across trials. A more detailed discussion of this study will follow.

From the data of previous experiments, no definitive conclusions can yet be drawn as to the validity of the associative symmetry principle. Previous evidence does indicate, however, the necessity of equating for stimulus availability before the dynamics of the bidirectional learning problem can be specified. Yet to be discussed is the importance of the difficulty of A-B versus B-A pairing and the importance of insuring stimulus and response equivalence.

A-B, B-A association equivalence

Ekstrand (1966) has argued that another important variable that must be controlled when testing for associative symmetry is the difficulty of associative pairing for each direction of learning. Due to the nature of the paired-associate task, a situation could arise where the A-B associative

pairing is intrinsically more difficult than the B-A pairing. Upon subsequent transfer to the backward learning task the experimenter might find B-A performance could surpass that of the A-B performance. Gallup and Wollen (1968) presented data which was interpreted to be contrary to the principle of associative symmetry. Stimulus-response availability was equated by using number stimuli and AA adjective responses. The results showed that S-R recall was greater than R-S recall when the materials recalled were single digit numbers. The reverse was true when the adjectives were the items to be recalled. It could be argued that the finding of the above experiment was due to an intrinsic difficulty in the adjective-number pairing. Since differential availability of the stimulus and response terms does not seem to be a relevant factor in this experiment, R-S performance superiority might be explained in terms of the initial ease of pairing in the number-adjective direction.

Richardson (1960) suggested that B-A performance on a test of associate symmetry ought to be compared to a control group that learned B-A in a forward direction. Although Gallup and Wollen (1968) used such a control, the data showed that the number of trials to criterion for the number-adjective pairing was consistently fewer than the trials to criterion for the adjective-number pairing. Again the data gave evidence of an intrinsic difficulty in the adjective-number direction.

Equating stimulus and response availability

Although stimulus availability has been discussed as one of the most important variables to be controlled in the testing of the symmetrical learning problem, failure to attend to response learning as a relevant variable could result in an inadequate test of B-A performance. Asch and

Linder (1963) have shown how a failure to equate for response learning could result in unexpected B-A performance. Using single digit numbers as stimuli and low meaningful CVC trigrams as responses, B-A performance was found to be superior to A-B performance if the S did not have the chance to complete the response learning of the trigrams.

In an analogous manner, Ney and Solso (1972) used high imagery-high concrete nouns as stimuli and low meaningful CVC trigrams as responses on an original learning list. The Ss were then transferred to an A-Br or B-Ar re-paired transfer list. Although the results showed identical performance for the transfer conditions as would be predicted by the principle of associative symmetry, the data presented equivocal evidence at best. It could be argued that because of the nature of the response terms, the B-Ar paradigm had actually engendered less interference than the A-Br paradigm. Equating for response availability might have resulted in a significant difference between the A-Br and B-Ar paradigm with the B-Ar paradigm yielding more interference than the S-Br paradigm. Such a finding would argue against the principle of associative symmetry.

In terms of learning and encoding of an experimentally induced association, it is important, then, to define the parameters of the associative symmetry principle. The formation of forward and backward associations might be a phenomenon of incidental learning only if the variables affecting learning performance are inadequately accounted for and controlled. The control of stimulus and response equivalence is therefore an important step in determining the validity of the associative symmetry learning principle.

Asch and Ebenholtz (1962) used a prefamiliarization technique in an

attempt to equate for the availability of the response term. This technique involved the giving of the stimulus and response terms to the S in a free learning situation. Presumably, the S learned the stimulus and response terms as individual units with any subsequent differences between A-B and B-A performance being due only to the effect of the associative stage. Several experimenters have pointed to the inadequacy of this technique by citing evidence which indicates that prefamiliarization could lead to abnormal effects of inhibition or facilitation (Simon & Wood, 1964; Underwood & Schulz, 1960).

Horowitz and Larsen (1963) stated that the prefamiliarization technique could engender interitem connections which could produce interference on the subsequent PA learning task. This interference would be analogous to the interference engendered by the A-B, A-Br negative transfer paradigm. In addition, it should be further noted that the equating of the availability of stimulus and response members would produce interference due to the existence of serial associations, grammar rules, and word-association hierarchies (Horowitz, Norman, & Day, 1966). The prefamiliarization technique is at best an inadequate method of insuring maximum stimulus and response availability.

Other experimenters have attempted to equate stimulus and response availability through the use of high meaningful trigrams and single-digits (Richardson, 1960). In this instance it was assumed that the numerals were pre-experimentally highly available to the S. The trigrams were actually three letter words thus insuring their availability. The results

of the experiment lended support to the principle of associative symmetry.

Another method of equating stimulus and response availability is through the use of colors and single-digit numbers for the stimulus and response terms respectively (Guirintano, 1972; Houston, 1964). In both of these previous experiments it had been assumed that color could function as an adequate functional stimulus (Underwood, Ham, & Ekstrand, 1962) and could therefore serve as a highly available stimulus item. Again it was assumed that the numbers would be preexperimentally highly available to the S. Houston (1964) reported finding no difference between forward and backward associations while Guirintano (1972) using a shorter intertrial interval (2:2 sec.) found significantly more forward than backward associations. The results of these two experiments lended support to the conclusion that stimulus-response availability is not a sufficient condition for the demonstration of the principle of associative symmetry. A methodological consideration for both of these experiments should be taken into account, however. Solso (1971) has demonstrated that colors differ along a continuum of meaningfulness and have a differential number of preexperimental associates. Due to the variability of meaningfulness in the color (stimulus) component, an interpretation of the results of the Houston (1964) experiment, should be tempered with the knowledge that meaningfulness was not held constant in the color component. The Giurintano (1972) study counterbalanced the A-B (color-number) condition and found no effect due to list conditions.

Still another method of equating for stimulus and response availability has been to use the stimulus component as a response component within the same list. This type of list structure involved the learning of the pairs

A-B and C-A within the same list. The double-function list insures that the S will learn the list components as both stimulus and response members (Horowitz, Brown, & Weissbluth, 1964; Umemoto & Hilgard, 1961; Young & Jennings, 1964). However serious methodological problems have arisen with the use of double-function lists (Ekstrand, 1966). Typically, B-A performance has been found to be poorer than A-B performance (e.g., Battig & Koppenaal, 1965). It has been suggested that forward associations appear to be stronger in the learning of double-function lists (each unit serves once as a stimulus and once as a response, in two different pairs) due to the competition between the two intralist associations.

Several experiments have also attempted to equate stimulus and response components by having the S learn bidirectionally (i.e., the S learns A-B and B-A alternately throughout the list) (Schild & Battig, 1966; Underwood & Keppel, 1963; Voss, 1965). The differences that have been found between forward and backward learning could have been attributed to the task demands of bidirectional learning. Bidirectional learning has been found to be inferior to unidirectional learning possible because the S has been "forced" to learn the stimulus and response components in the dual role of both stimulus and response.

Summary

The review of past literature, has shown the importance of defining the methodological problems involved in the testing of the principle of associative symmetry. It is evident from previous data that symmetrical learning obtains only under very specified conditions of methodological control. Insuring stimulus availability, equating both stimulus and response availability, and eliminating any effect due to difficulty of

pairing direction are at least some of the variables and conditions that must be considered if incidental learning is to be separated from the associative learning phenomenon.

The wider implications of bidirectional learning for a general theory of learning and a proposed design for the testing of bidirectional learning should be discussed if definite conclusions can be made concerning the principle of associative symmetry.

CHAPTER III

Transfer and Bidirectionality

The transfer implications of the bidirectional learning problem must be considered if incidental learning is to be separated from symmetrical learning. Further, the nature of the associative stage in paired-associate learning can perhaps be best delineated and defined by the use of transfer paradigms.

Several investigators have specified the transfer effects of various paired-associate paradigms (Gagne, Foster, & Crowley, 1948; Mandler & Heineman, 1956; Murdock, 1957; Porter & Duncan, 1953; Postman, 1966; Twedt & Underwood, 1959). For the purposes of studying bidirectional learning, the use of the negative transfer paradigms has yielded results relevant to the study of associative symmetry. Previous experiments have shown that the A-B, A-Br paradigm typically produces negative associative transfer effects. Porter and Duncan (1953) reported negative transfer results when the materials used were two-syllable adjectives. The negative transfer was hypothesized to result from interference from both the forward and backward directions (Ekstrand, 1966). According to a general theory of bidirectional learning, it has been hypothesized that during the learning of original list items a S has developed both forward and backward associations. When transferring to the re-paired (A-Br) list, interference is generated from the combined effects of forward and backward associations. If, for example, S has learned the association of A_1-B_1 on the original list learning and is then transferred to a list containing the pair A_1-B_3 , interference arises from the latent A_1-B_1 association and the latent B_3-A_3 association. Ekstrand (1966) stated that both associations conform to an

A-C paradigm. If symmetrical learning is more than an incidental learning phenomenon, then the negative transfer effects of the A-Br paradigm must be greater than that of the C-B or A-C paradigms. Several experimenters have reported data suggesting that the negative effects do arise from both forward and backward associations (Jung, 1962; McGovern, 1964; Twedt & Underwood, 1959).

Murdock (1956, 1958) reported data from two experiments which supported a symmetrical view of bidirectional learning. In the 1956 study, Murdock compared an A-B, A-Br paradigm with an A-B, B-Ar paradigm with control learning of new items. The re-paired paradigms both showed negative transfer in relation to original list (A-B) learning, but did not differ in their relative amounts of negative transfer. Murdock (1958) compared two transfer paradigms (A-B, B-C; A-B, C-A) which were hypothesized to yield negative transfer effects on the basis of backward associations. Both transfer conditions showed negative effects in relation to a C-D control paradigm. Murdock also compared the B-C and C-A paradigms with an A-C paradigm which yields negative transfer from the original list forward associations. If bidirectional learning is a form of incidental learning then the A-C paradigm should have shown more negative transfer than either the B-C or C-A conditions. The incidental learning argument predicts that because the observed backward association was formed incidentally to the forward association, the R-S association should be weaker. The interference engendered by the backward learning on the subsequent transfer should also be less than the interference from the forward learning. All three of the paradigms reported by Murdock (1958) produced equal negative transfer. This result indicated that the forward

and backward associations formed during the initial learning were equal, thus supporting a symmetrical learning argument.

Other investigators have also found equal transfer effects using paradigms in which the negative transfer results from forward and backward associative interference (Harcum, 1953; Johnston, 1968; Ney & Solso, 1972). Johnston (1967) used 4-stage transfer paradigms as a measure of associative symmetry. The results of the experiment indicated that R-S associations are formed during S-R learning and high stimulus availability is only necessary for R-S recall but not for the formation of the R-S association. R-S associations were exposed when the stimulus terms were made available after the termination of S-R learning. Johnston (1967), however, failed to find bidirectional interference in the C-A paradigm. In a subsequent experiment Johnston (1968) explained this result by stating that A-B and B-A associations appear interdependent only if the conflicting associations in the transfer list are directionally the same. Clearly in the C-A paradigm the associative conflict arises between the forward C-A association and the backward B-A association. According to this interpretation both the A-C and C-B paradigms should yield results supporting the principle of associative symmetry. This inference, however, cannot explain the results of the Murdock (1956) experiment which used the A-Br and B-Ar paradigms.

The present study was an attempt to use the concept of associative interference in negative transfer paradigms as a method of proving the principle of associative symmetry. It was hypothesized that the negative transfer paradigms (A-Br and B-Ar) would prove to be the most effective means of isolating the associative stage of learning. The use of re-paired

paradigm also eliminated the potential problem of forward rehearsal during the R-S transfer task.

The present study also employed a 2:2 anticipation rate in order to eliminate the problem of giving the S too much time for the study of the response component in the R-S learning task. It was hypothesized that given too much time to study the R component in the transfer task, the S would recall all of the forward associations in an attempt to find the correct R-S pairing. The use of the short inter-item time and re-paired paradigm eliminates at least one important methodological confound in previous bidirectional learning experiments.

The present study also used high concrete and high imagery stimulus and response items. The use of these types of paired-associate components eliminated the problem of differential item availability and insured stimulus availability.

As a review of previous literature indicated, the problem of unequal difficulty in direction of pairing was typically encountered when the stimulus and response items were of differential meaningfulness or from different semantic classes (e.g., adjectives and numbers). Therefore, the use of high imagery and high concrete nouns in a random pairing eliminates the problem of pairing direction difficulty. The effect of individual idiosyncratic pairing difficulty was hypothesized to be eliminated by the randomizing of this effect across subjects.

Specifically it was hypothesized that if bidirectional learning is operative in paired-associate learning tasks, then the A-Br and B-Ar paradigms would show equal negative transfer effects in relation to a C-D control condition. The incidental learning argument would predict that

the B-Ar paradigm would show less negative transfer than the A-Br paradigm because the B-A association was formed incidentally to the intentionally learned A-B forward association.

CHAPTER IV

Method

Subjects

The Ss were introductory psychology students whose participation partially fulfilled a course requirement. For each of the three paradigm conditions (A-B, A-Br; A-B, B-Ar; A-B, C-D), 15 Ss were randomly assigned to each group. A total of 64 Ss participated in the experiment with four Ss being eliminated for failure to follow instructions.

Materials

The stimulus and response components of the A-B, A-Br; A-B, B-Ar, A-B, C-D paired-associate lists were 36 nouns chosen from the Paivio, Yuille, and Madigan (1968) norms. All of the nouns were rated high in both imagery and concreteness (above 6.50). The words were randomly divided into individual lists of nine stimulus and response pairs, and obvious associates were eliminated. First letter associates between the stimulus and response components were also eliminated. Intra-item similarity was minimum. The re-pairing of the A-B list into the A-Br and B-Ar transfer list was random with obvious paired-associates being eliminated. The re-pairing of the list components for both of the repaired conditions was identical in order to equate for possible idiosyncratic ease of pairing for particular associates. Any pairs showing obvious direction-of-pairing difficulty were eliminated.

In order to insure that the A-B and C-D lists were equated not only for imagery and concreteness but also for equality of pairing, the presentation of the A-B and C-D lists was counterbalanced.

Four randomized orders of the original and transfer lists were constructed in order to discourage serial position effects.

Design

The design was a single level design with the variable being effect or transfer paradigm (A-Br, B-Ar, C-D) with a trials criterion measure as the independent variable.

Procedure

The pairs for all of the lists were presented on a Stowe memory drum using a standard anticipation method. The intratrial time was 2:2 seconds and intertrial time was 4 seconds. The Ss were required to learn the A-B lists to a criterion of two perfect trials and the subsequent transfer list to a criterion of one perfect trial. During initial acquisition each S was instructed to articulate both the stimulus and response terms. Guessing was encouraged. The remainder of the instruction followed standard paired-associate procedure.

For one-half of the Ss in the control condition the A-B list was presented first followed by the transfer to the C-D list. For the other half of the Ss the C-D list preceded the A-B list. This procedure was employed in order to insure list comparability in the C-D control paradigm.

Following first list acquisition Ss were asked to learn a transfer list. Second list responses had to be correctly paired with their stimuli in order to be considered correct. The trials to a criterion of one perfect trial were measured for each of the transfer paradigms (A-Pr, B-Ar, C-D).



CHAPTER V

Results and Discussion

It had been hypothesized that bidirectional learning could be demonstrated to be an instance of symmetrical learning with the use of a re-paired transfer paradigm (B-Ar). It had been further hypothesized that when compared to the standard control paradigm (C-D), the B-Ar paradigm would show negative transfer equal to that exhibited by the A-Br paradigm. Both of the re-paired paradigms were hypothesized to show significant negative transfer when compared to the C-D control condition.

The list presentation for the control condition was counterbalanced. The analysis of variance on the effect of list structure for the A-B and C-D lists is presented in Table 1. An analysis of variance indicated that the trials by condition interaction was nonsignificant. The C-D list was therefore judged to be an appropriate control condition for the re-paired paradigms.

For the purpose of further analysis the data from the counterbalanced A-B, C-D condition was "collapsed." whichever list was presented first, regardless of list structure, was considered to be the A-B list. The original list learning of the three transfer conditions was then compared in order to insure first list learning comparability. The trials to criterion for the A-B list learning are presented in Table 2.

Observation of the data revealed no differential rates of learning on the A-B list; therefore, any differences in trials to criterion on the transfer could not be ascribed to differences in the amount learned during initial acquisition.

The results of a planned comparison analysis of the three transfer

Table 1

Analysis of Variance

Counterbalanced Presentation of the A-B and C-D List Orders

Two Factor Mixed Design: Repeated Measure on One Factor

Source	SS	df	MS	F	p
Total	1260.37	39			
Between Subjects	347.87	19			
Condition	30.62	1	30.62	1.74	N.S.
Error _b	317.25	18	17.63		
Within Subjects	1229.75	20	61.49		
Trials	600.62	1	600.62	18.29	p < .001
T x C	38.03	1	38.03	1.16	N.S.
Error _w	591.10	18	32.84		

Table 2
Trials to Criterion on A-B List Learning
for Each of the Transfer Conditions

<u>Transfer Condition</u>	<u>Trial to Criterion</u>
A-B, C-D	13.75
A-B, A-Br	13.70
A-B, B-Ar	14.15

conditions are summarized in Tables 3 and 4.

The data confirmed the hypothesis of significant negative transfer for both of the re-paired paradigms in relation to a standard control paradigm, $F(1, 57) = 4.42, p < .05$. Further, both of the re-paired conditions showed equal transfer effects on a trials to criterion measure, $F(1, 57) = 0.30, p = N.S.$.

The present study attempted to eliminate the methodological problems which have precluded a clear interpretation of previous experiments. The choice of stimulus and response terms were calculated to eliminate differential item availability. There was no indication of idiosyncratic difficulty in direction of pairing; thus the effects of the re-paired transfer paradigms could not be explained by ease of pairing in either the forward or backward direction.

The data also clearly showed that stimulus availability was accounted for by the use of high imagery and high concrete nouns. Thus any indication of symmetrical learning could not be attributed to the effect of item availability.

The present experiment indicated that an incidental learning argument for the bidirectional learning issue could not be accepted on the basis of the data obtained. If the R-S association was learned incidentally and was weaker than the intentionally-learned forward association, then the B-Ar condition should have engendered less negative associative transfer. However, the A-Br and B-Ar conditions yielded equal associative transfer in relation to the C-D control paradigm. The principle of associative symmetry would predict the above result by postulating that the forward and backward associations on the original list were learned with equal

Table 3
Analysis of Variance for the Three Transfer Conditions
(C-D, A-Br, B-Ar)

Source	SS	df	MS	F	p
Treatment	47.43	2	23.72	2.36	N.S.
Error	572.75	57	10.05		
Total	620.18	59			

Table 4
Planned Comparison of the Three Transfer Conditions
(C-D, A-Br, B-Ar)

Source	SS	df	MS	F	p
A-Br vs. B-Ar	3.03	1	3.03	0.30	N.S.
C-D vs. (A-Br, B-Ar)	44.41	1	44.41	4.42	$p < .05$

strength. The data, therefore, supported the principle of associative symmetry and indicated that the incidental learning argument was not a valid explanation in the present study.

Further, the data also indicated that associative symmetry is not only obtained in those transfer paradigms where the direction of interference was either forward or backward or both. Clearly, the re-paired paradigm (B-Ar) yielded symmetrical learning results although the locus of interference was from both forward and backward associations.

A problem arises when attempts are made at generalizing the results of this type of experiment to a larger theory of learning. The principle of associative symmetry appears to be operative in only tightly controlled laboratory situations. Rarely in nonexperimental settings will the experimenter find equal item availability, constant meaningfulness, and ease of direction pairing. However, given the controls specified previously in this study, associative symmetry should obtain. In those instances where the proper controls are employed, it can be proven that bidirectional learning is more than an instance of incidental learning.

The present data supports the interpretation that bidirectional learning is symmetrical and that the forward and backward associations are functionally identical. Further research may delineate the precise effect of associative symmetry on other transfer paradigms and resolve the discrepancy between Johnston's (1968) inference and the data obtained in the present experiment. Johnston (1968) had inferred that data supporting associative symmetry might only be obtained with those transfer paradigms in which the associative interference was unidirectional. However, the present experiment yielded results contrary to this argument. Further

research should be directed toward clearly specifying the role of uni- and bidirectional interference in the paired-associate paradigms.

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APPROVAL SHEET

The Thesis submitted by Richard C. Ney has been read and approved by members of the Department of Psychology.

The final copies have been examined by the director of the Thesis and the signature which appears below verifies the fact that the Thesis is now given final approval with reference to content and form.

The Thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

May 21, 1973
Date

Robert L. Sells
Signature of Advisor